ANSWERS TO PROBLEMS IN
ELECTRICAL ENGINEERING SCIENCE

by

Preston R. Clement
Walter C. Johnson

Chapter I.

1.2 5.1 meters

1.5 a $18\pi \times 10^9 p_A$ volts/meter

b $18\pi \times 10^9 p_A$ v/m

1.6 a $\sqrt{3}$

b $\sqrt{3}$

c vector of unit length along + z axis

d vector of unit length along -z axis

e $\sqrt{3}$ c

f $\sqrt{6}$ in -z direction

g $\sqrt{2}$ in -y direction

1.8 46.6 joules

1.9 $(qp_A r/\epsilon_o) \sin \omega t$

1.10 $(2/3)\, u_o d$ m^3/sec

1.13 $2.25 \times 10^9 (q/d)^2$

1.14 $9 \times 10^9 (p_L^2/d)$

1.15 1/2 volt/meter at an angle 45°

1.16 a 1540 v/m, 180°

b 625 v/m, 180°

c 2280 v/m, -113°

d 910 v/m, 108°

1.17 a 5.94×10^6 m/sec

b 1.602×10^{-17} joule

c 0.5 watt

1.18 9.2×10^5 m/sec

1.20 a 546 volts

b 1370 volts

1.21 9.08×10^{-7} coul/m^2, -9.08×10^{-7} coul/m^2

1.22 1.11×10^{-6} coul/m^2

1.23 395 volts

1.24 a -5.0×10^{-7} coul/m^2

b $+7.5 \times 10^{-7}$ coul/m^2

c -2.5×10^{-7} coul/m^2

1.25 a $D = p_L/2\pi r$ coul/m^2

b $= p_L/2\pi r K \epsilon_o$ v/m

c $(p_L/2\pi K \epsilon_o) \ln(b/a)$ volts

d $2\pi K \epsilon_o / \ln (b/a)$ farads

1.26 $K(r) = K_a (a/r)$

1.27 $D = v/r \frac{1}{\epsilon_1} \ln \frac{b}{a} + \frac{1}{\epsilon_2} \ln \frac{c}{b}$, $E_1 = D/\epsilon_1$, $E_2 = D/\epsilon_2$

1.28 a 1.74×10^{-12} coul/m

b $5.5 \times 10^{+12}$ m/sec^2, 0.328mm

1.29 a 1.67 meters

b 9.26×10^{-4} coul

c 5.78×10^{15} electrons

1.31 $D = q/4\pi r^2$, $q/4\pi r^2 \epsilon_1$, $q/4\pi r^2 \epsilon_2$

1.32 Breakdown just outside r= r_2, 1800 volts.

1.34 JA cos θ

1.35 a 2×10^{-8} sin (1000t) coul.

b 2×10^{-5} cos (1000t) amp.

chapter 2

2.2 4.55×10^{-12} sec.

2.3 Assume one free electron per atom
$18.3\ cm^2$/volt-sec.

2.4 $p = 5.94 \times 10^{-11}\ (T+273)$ ohm-meter

2.6 a -234°
b 0.00324

2.7 $84^\circ C$

2.8 a 0.0269 volt/meter
b 2.69 volts
c 41,600 watts/m^3

2.10 0.49 ohm-meter

2.11 1.73×10^{-3} ohm-meter

2.22 ~2.5 ohm, ~200 megohms

chapter 3

3.1 1.60×10^{-17} nt

3.2 o.506 weber/m^2, +xdirection

3.3 0, $q\omega^2 r B \sin\theta$, 0, $q\omega^2 r B \sin\theta$

3.4 b $1/Nq$ c 1.13×10^{29} electrons/m^3,
8.40×10^{28} atoms/m^3

3.5 4.51×10^{-4} weber/m^2

3.6 22.5 lb.

3.7 a $J = B\,(2h)\,iaN$
b $\theta = \frac{2BhNai}{k}$

3.9 $\frac{w}{2} \ln (1 + h^2)$

3.10 b $\underset{\sim}{J} = \underset{\sim}{m} \times \underset{\sim}{B}$

3.11 1.48×10^{-23} amp-$meter^2$

3.12 a 15.9 amp/m
b 596,000 amp/m
c 796,000 amp/m

3.13 $\frac{uNiw}{2\pi} \ln \left(\frac{b}{a}\right)$

3.16 a 5060 amp-turns
c 3.23×10^{-2} volt/m,
1.57×10^{-2} volt/turn,
5100 turns, 9.93×10^{-4} in^2,
0.993 amp

3.17 a 25.8"
b 2.53×10^5, 9.79×10^5
c 3.07 amp

3.18 a 0.66 meter

3.19 B = 1.3 webers/m^2, B=1.18 w/m^2,
B = 0.8 webers/m^2

3.20 b 1.0 weber/m^2, -46,000amp/m
c 13 cm^2, 5.65 cm
d 4.98 cm

3.21 a 20.4 cm^2, 4.5 cm
b 6.24 cm

3.22 a 1.44 b 1.21

3.23 a 1.19×10^5 $\frac{\text{amp-turn}}{\text{weber}}$
b 1.19×10^6

3.26 0.71 cos 377t volt

3.28 1.08×10^{-3} sin 3770t volt

3.30 $\frac{r}{2}\frac{dB}{dt}$, Counter-clockwise direction as viewed from top.

3/32 V_1 = 1.4 volts(top terminal positive)
V_2 = 0.6 volt (bottom terminal positive)
V_3 = 1 volt (left terminal pos.),
V_4 = 2 volts (" " ")

3.33 a $(a^2 d/4p)(dB/dt)$ amp

3.34 $uN^2 i^2 A/2\ell$ joules

3.35 50

3.36 1.02×10^4 joules, 15.5 meters

3.37 c 1.02×10^6 nt or 115 tons,

d 39.8 nt or 8.96 lb.

3.39 5.37 μsec/mi

3.40 a 1.33×10^{-5} sin 2πft amp/m

b 41.9 cos 2πft μv.

CHAPTER 4-

4.1 $f \leq 600$ cps

4.2 1.72×10^{-8} ohm-meter

4.3 33.3 ohms

4.4 $(p/2\pi)\, \ell n(r_2/r_1)$

4.5 864 joules/sec, 16.7 ohms

4.8 22.1 μμf.

4.9 160 μμf/meter

4.10 $3\epsilon_o \pi R^2/d$

4.11 $4\pi\epsilon/(\frac{1}{a}\frac{1}{b})$

4.14 1.0"

4.15 $(k/4)\, v^{4/3}$

4.16 $\mu N^2 A$ henrys/meter

4.17 a $2.55N^2 \times 10^{-7}$ henry

b $2.28N^2 \times 10^{-7}$ henry

4.18 10.6 ft-lb

4.19 a $L_1 = N_1^2 \mu_o A_1/\ell$

b $L_2 = N_2^2 \mu_o A_2/\ell$

c $N_1 N_2 \mu_o A_2/\ell$

d $\sqrt{A_2/A_1}$

4.20 0.0286 μh

4.21 80 joules, 20 joules

4.22 a 0.633 weber/sec

b 0.027 weber/sec

4.24 a 0.5 amp

b 500 amp/sec

4.25 1.20 amp

4.26 a -1.5 amp

b 1000 amp/sec

c -51,000 amp/sec

4.27 1.0 amp, 800 amp/sec

4.28 0.25 μf

4.29 300 ohms, 0.067 μf

4.30 a 33/56 ohm b 33/56 mh

c 56/33 μf

4.31 $C(dv_c/dt) + v_c/R = e/R$

4.33 $e_1(t) = L(di_1/dt) + R_1(i_1+i_2)$;

$e_2(t) = R_2 i_2 + R_1(i_1+i_2)$

4.36 a $e_o(t) \doteq e(t)$

b $e_o(t) \doteq 0$

4.38 a $e_o(t) \doteq E$

b $e_o(t) \doteq e(t)$

4.42 V = 3 volts

4.43 1.0 amp.

4.44 2.78 amp, -1.11 amp, 1.67amp

4.45 -0.3 amp

4.46 1.8×10^{17} ohm, 250 μμf

4.48 1.67 amp

4.49 -48 volts

4.52 1.15×10^{-2}

CHAPTER 5

5.3 a $\epsilon_o R^2 V^2 t/8d(2d+t)$

5.4 $0.556\ m^2$

5.5 a 1000 cps

b $4.43 \times 10^{-9}\ (2\times10^6 \equiv 25 + 2\times10^4 \sin 2000\pi t - 25 \cos 4000\pi t)$ nt

c 0.125%

5.6 a $B_g^2 A/2\mu_g$

c $(1/2)\ \phi^2\ (dR/dx)$

5.7 a 6.3 inches

b 37 lbs. , 12.8 inches

5.9 a 120 cps b $f = pn/120$

5.11 a $\phi_o/\sqrt{1 - (2E^2/JR\omega_o^2)}\ t = \phi$ where $\phi_g = E/k_g\omega_o$

b $JR\omega_o^2/2E^2$ sec.

5.12 a About 220 ohms

b 165 ohms

c E_g = 230 v.

5.13 232 volts

5.14 2530 rpm, 1520 rpm, 1280 rpm, 1080 rpm

5.15 a 12,500 nt-m, 9230 lb-ft.

b 0.759 ohm, 0341 ohm

5.16 a 407 watts

b 91.3% , 40.5 hp.

5.17 a 1053 rpm

b 1.17 ohms

c 600 rpm

CHAPTER 6

6.4 a $2I_m/\pi = 0.636\ I_m$, $\frac{I_m}{\sqrt{2}} = 0.707\ I_m$

b $\pi/2\sqrt{2} = 1.11$

6.6 a $10/\sqrt{2} = 7.07$ amp

b $10/\sqrt{3} = 5.77$ amp

6.9 9.1 amp

6.11 a Radius = 0.15 meter

6.12 84.1 volts

6.13 a 0.003334 ohms

b 0.003333 ohms

6.14 a 49,990 ohms

b 100 ohms/volt

6.15 4.50 megohms

6.16 1.92 ma.

6.17 a 40% ; 10^{-6}%

b 1.3×10^{-5}%; 5%

c 12.3 ohms

6.21 0.707 rad

6.22 $0.0292\ weber/m^2$

6.23 11.1 volts or 2.22 volts

6.24 7.6%

6.27 $r < 461$ ohms

6.28 $\frac{1}{2}(\ell/2 + L)\ell/bV_a$

6.30 40°

CHAPTER 7

7.1 a $i = 0.143\epsilon^{-87.5t}$ amp

b $W = 0.00819\epsilon^{-175t}$ joules

7.3 a 0.0187 sec

7.4 $i = I_o\ (1 - t/\tau)^{R_o\tau/L}$

7.6 a $W = W_o \epsilon^{-2t/RC}$ joules

b 2.3, 3.45, 4.6

7.9 a 0.833 μsec.

b $i = \epsilon^{-1.20 \times 10^{+6t}}$ amp

c $v_1 = 11.7 - 1.7\epsilon^{-1.20 \times 10^{6t}}$ v,

$v_2 = 11.7 + 8.3\epsilon^{-1.20 \times 10^{6t}}$ v.

7.11 0.2 sec.

7.12 $i = 10\epsilon^{-25t}$ for $0 < t \leq \frac{1}{25} \ln 2$

$i = 5\epsilon^{-\frac{25t}{7}}$ for $t \geq \frac{1}{25} \ln 2$

7.13 $i = I_o \cos \frac{t}{\sqrt{LC}} - V_o \sqrt{C/L} \sin t/\sqrt{LC}$

7.16 1.15×10^5 rad/sec., 1410 rad/sec.

7.18 $i = \epsilon^{-\frac{Rt}{2L}} \left[I_o \cos \omega t + \frac{1}{\omega L} \left(V_o - \frac{RI_o}{2} \right) \sin \omega t \right]$

where $\omega = \sqrt{\frac{1}{LC} - \frac{R^2}{4L^2}}$, or

$i = \epsilon^{-\frac{Rt}{2L}} \left[I_o \cosh \beta t + \frac{1}{\beta L} \left(V_o - \frac{RI_o}{2} \right) \sinh \beta t \right]$

where $\beta = \sqrt{\frac{R^2}{4L^2} - \frac{1}{LC}}$

7.19 a 892 ohms

b 2.32 millisec.

7.22 a 800 ohms

b $i = 0.545\epsilon^{-1370t} \sinh 573t$ amp.

7.23 a 54.5 cps.

b 63.0 cps.

c 0.20 amp.

d 0.636 henry, 254 ohms

e 50.8 volts, 49.2 volts

7.24 a $i = \frac{1}{R} \epsilon^{-\frac{t}{2RC}} \left[V_o \cos \omega t + \frac{1}{\omega C} \left(I_o - \frac{V_o}{2R} \right) \sin \omega t \right]$

where $\omega = \sqrt{\frac{1}{LC} - \frac{1}{4R^2C^2}}$

b $i = \frac{1}{R} \epsilon^{-\frac{t}{2RC}} \left[V_o \cosh \beta t + \frac{1}{\beta C} \left(I_o - \frac{V_o}{2R} \right) \sin \beta t \right]$

where $\beta = \sqrt{\frac{1}{4R^2C^2} - \frac{1}{LC}}$

7.26 $R > 100$ ohms

7.27 a 55.7 cps; b 68.3 cps;

c 1.50 amp; 0.75 amp;

d 133 ohms, 0.363 henry

7.28 $\omega = \omega_o \epsilon - k^2 t / JR$

CHAPTER 8

8.3 $i = K/R \left[t - L/R \left(1 - \epsilon^{-Rt/L} \right) \right]$

8.4 $i = E_o / -\omega L + R \left[\epsilon^{-\omega t} - \epsilon^{-Rt/L} \right]$

8.9 2000 volts

8.10 $i = \frac{NBA}{L}$

8.12 2.5 amp, -6.25×10^5 amp/sec.

8.13 a $\frac{1}{4}$ amp; b 2 volts; -10 volts

8.14 a 0.45 amp; b 11 joules

8.17 $v = 16.7 \left(1 + 5\epsilon^{-1200t} \right)$ volts

8.19 a $E\epsilon^{-t/RC}$

b $E\epsilon^{-t/RC} \left(\epsilon^{T/RC} - 1 \right)$

8.22 $v_1 = -\frac{E}{2}\epsilon^{-t/2RC}$, $v_2 = \frac{E}{2}\epsilon^{-t/2RC}$

8.23 a 0.63 b 4.8%

8.24 $i = \left(\frac{L_1}{L_1 + L_2} \frac{E}{R_1} - \frac{E}{R_1 + R_2} \right) \epsilon^{-\frac{(R_1 + R_2)}{L_1 + L_2} t} + \frac{E}{R_1 + R_2}$

8.27 a $i = \frac{E}{2\omega_n L} \epsilon^{-Rt/2L} \sin \omega_n t$

b $i = \frac{E}{2\omega_o L\sqrt{1-\zeta^2}} \epsilon^{-\zeta\omega_o t} \sin \omega_o \sqrt{1-\zeta^2}\, t$

8.30 $v = \frac{I_o}{\omega_n C} \epsilon^{-t/2RC} \sin \omega_n t$

8.32 $\theta = I_o \frac{k}{K}\left[1-\epsilon^{-Bt/2J}\left(\cos\omega_n t + \frac{B}{2\omega_n J}\sin\omega_n t\right)\right]$

where $\omega_n = \sqrt{\frac{K}{J} - \frac{B^2}{4J^2}}$

8.33 $B^2 = 1.44\ KJ$

8.35 a $v_R = 100(\epsilon^{-100t} - \epsilon^{-200t})$

b $v_R = 20{,}000t\epsilon^{-200t}$

8.38 $v_c = 100 + 160\epsilon^{-1000t} - 260\epsilon^{-2000t}$ v

8.39 $i = 10 + 10\epsilon^{-100t} - 18\epsilon^{-200t}$ amp

8.44 a $-2A\epsilon^{-t/RC} + 2A\epsilon^{-t/2RC}$

b $\frac{A}{RC}\, t\epsilon^{-t/RC}$

8.46 a $i(t) = \frac{A\cos(\omega t - \tan^{-1}\frac{\omega L}{R})}{\sqrt{R^2 + \omega^2 L^2}} + \frac{AR}{R^2+\omega^2L^2}\epsilon^{-Rt/L}$

b $t = \frac{1}{\omega}(\pi + \tan^{-1}\frac{\omega L}{R})$

CHAPTER 9

9.1 a b = 12, n = 10

9.3 a b = 28, n = 16; b Yes, 13

9.4 $\sqrt{\frac{L}{2W_L}}\frac{dW_L}{dt} + R\sqrt{\frac{2W_L}{L}} = E$

9.5 $\frac{C}{2W_C}\frac{dW_C}{dt} + \frac{1}{R}\sqrt{\frac{2W_C}{C}} = \frac{E}{R}$

9.12 a 7, 5; b No.; C Yes

9.14 a 7,3

9.15 a $A_1\epsilon^{p_1 t} + A_2\epsilon^{p_2 t}$ where

$p_1, p_2 = \frac{1}{2R_2C^2L}\left[-(LC+R_1R_2C^2) \pm \sqrt{(LC+R_1R_2C^2)^2 - 4(R_1R_2)R_2C^3L}\right]$

b When $R_1R_2 = \frac{L}{C}$, $\omega_n = \omega_o$

9.16 $i = 0.375 + 0.147\epsilon^{-569t} - 1.522\epsilon^{-281}$ amp.

9.17 $\omega = 14.7 + 3.06\epsilon^{-2.06t}\cos(5.89t + 51.$ rad/sec.

9.18 $v = 3.78\epsilon^{-0.202t} + \epsilon^{0.099t}$

$(-3.78\cos 1.145t + 0.341 \sin 1.145$

9.19 $D^2x = 5, D^2y = 5$

$D^3x = \frac{-25}{4}$, $D^3y = -\frac{55}{8}$

CHAPTER 10

10.1 a $v = 163\cos(2510t + 52.1^\circ)$ v.

b 2π sec.

10.3 $A\sin(\omega t + 94^\circ)$

10.4 a $11.2\cos(\omega t - 63.4^\circ)$

b $-8.95\cos(\omega t + 63.4^\circ)$

c $-5.58\sin(\omega t + 15.6^\circ)$

d $17.4\sin(\omega t + 46.6^\circ)$

10.5 $12.8\cos(\omega t + 15.9^\circ)$ amp

10.6 a $v_{14} = -55.4\sin(100t + 47.5^\circ)$ v

b $-95\sin(100t - 9^\circ) - 80\cos(200t + 4$ V.

10.8 a 0.0377 ohms, 26.5mhos

10.9 a 1000 ohms, 0.001 mho

10.10 a 18.8 ohms, 0.053 mho

b 94 volts

10.11 a 53 ohms, 0.0188 mho

b 265 volts

10.12 a 85.3 $\angle 62^\circ$ ohms

b 1.41 amp

10.13 a 8.94 amp

b 5.55 amp

10.14 a $44.7\cos(100t+63.5^\circ)$ v.

b $83.3\cos(300t+33.6^\circ)$ v.

10.15 a $i=7.83\cos(314t+38.5^\circ)+3.89\epsilon^{-250t}$ ma.

b 15.6 v.

10.17 a $i_{ss} = 0.707\cos(1000t+45^\circ)$ amp

10.18 53.6°

CHAPTER 11

11.1 a -1-j1, -5+j9

b 14+j23, $-0.897-j0.241$

11.4 a $(100\epsilon^{-j60^\circ})\epsilon^{j\omega t}$

b $(100\epsilon^{j120^\circ})\epsilon^{j\omega t}$

c $(-20\epsilon^{j20^\circ})\epsilon^{j2\omega t}$

d $(7\epsilon^{-j80^\circ})\epsilon^{j200t}$

e $(+14\epsilon^{j90^\circ})\epsilon^{j377t}$

f $(155\epsilon^{-j110^\circ})\epsilon^{j377t}$

11.5 b $\underline{V} = \dfrac{\underline{E}}{1+j\omega RC}$

c $v(t) \dfrac{E_m}{\sqrt{1+\omega^2R^2C^2}}\cos(\omega t-\tan^{-1}\omega RC)$

11.6 a $\underline{U}_m \dfrac{\underline{F}}{(a_o-a_2\omega^2)+j\omega(a_1-a_3\omega^2)}$

b $u(t) \dfrac{F_o}{\sqrt{(a_o-a_2\omega^2)^2+\omega^2(a_1-a_3\omega^2)^2}}\cos\left(\omega t+\alpha-\tan^{-1}\dfrac{\omega(a_1-a_3\omega^2)}{a_o-a_2\omega^2}\right)$

11.7 $u = 2.24\cos(2t+40.8^\circ)$

11.8 c $i_2=1.66\cos(377t-56.4^\circ)$

$-0.92\epsilon^{-250t}$ amp.

11.9 c $v=5.95\cos(6280t-85.44^\circ)$

$-0.473\epsilon^{-500t}$ v.

11.11 c $i_1=2.87\cos(377t-39.4^\circ)$ amp

11.13 a $42.0\angle 27^\circ$ ohms, $0.0238\angle -27^\circ$ mho

* See Bottom for b/c 0.0212 mho, -0.0108mho (inducti

11.14 a $44.5\angle -48^\circ$ ohms, $0.0225\angle 48^\circ$ mho

b 29.8ohms, -33.0ohms (capacitive

c 0.0150mho, 0.0167mho (")

11.16 a 1.55-j10.6ohms, R = 1.55ohms, X = -10.6ohms

b 0.0135+j0.0924mho G=0.0135mho, B=0.0924mho

e 0.66 amp

11.17 $i=0.70\cos(377t+32.6^\circ)+\epsilon^{-120t}$

$(0.59\cos430t+0.54\sin430t)$ amp

11.21 a 1.59 cps

b $\theta=1.0+0.381\cos(6.28t-21^\circ)$ ra

c $\theta \cong 1.0+0.0028\cos(377t-171^\circ)$ rad

11.22 a $\theta=0.5+0.443\cos(12.56t-41.7^\circ)$ r

b $\theta=0.5+0.00088\cos(754t-175^\circ)$ ra

11.24 $\pm 72^\circ$, $\pm 45^\circ$

11.25 b 30 $\pm$ j177 ohms

11.26 1.18 amp

11.27 16.2 ohms

11.28 b 5.6 ohms

* 11.13 b 37.4 ohms, 191 ohms (inductive

CHAPTER 12

12.1 $71.5 \angle -69.5^\circ$ v.

12.2 $2.50 \angle 90^\circ$ amp.

12.4 $0.188 \angle 27.6^\circ$ amp; $7.09 \angle -13.4^\circ$ v.

12.5 a $\underset{\sim}{V} = 26.9 \angle 6.25^\circ$ v.

12.7 $\underset{\sim}{Z}_{ab} = 2.78 - j0.30$ ohms;
$\underset{\sim}{Y}_{ab} = \frac{1}{2.81} + \frac{1}{-j26.0}$ mho

12.10 a 37 ohms; 2.70 amp
b 0.54 amp

12.11 7/12 ohm

12.14 $f = \frac{1}{2\pi RC}$ cps

12.16 a 2.37 v; 21.2 v
b 21.3 v

12.28 a $v_c = E/4(1 - \epsilon^{-2t/3RC})$ v
b $E/4 - E/12(\epsilon^{-2t/3RC})$ amp

12.29 a $i_L = E/9R(1 - \epsilon^{-3Rt/L})$
b $E/R(4/27 - 1/27(\epsilon^{-3Rt/L})$ amp

12.30 b $1.25 \angle 90^\circ$ amp

12.34 110 volts; 6.4 ma.

12.35 0.69 ma.

CHAPTER 13

13.1 20 watts

13.2 4 joules/cycle

13.9 $1/2\ LI^2(1+\cos 2\omega t)$ joules;
$1/2\omega^2 C\ I^2(1-\cos 2\omega t)$ joules
a $1/2\ LI^2(3 - \cos 2\omega t)$
b LI^2 (constant)
c $1/4\ LI^2\ (3 + \cos 2\omega t)$

13.11 a $650+650\cos 2\omega t - 375\sin 2\omega t$ w.
b 650 watts
c 375 var leading d 750 v-a

13.13 a 1500 watts; 2600 var leading;
3000 v-a
c 480 watts; 140 var lagging;
500 v-a

13.15 20.3 ohms

13.17 a 750 KVAR
b 2110 KVAR

13.18 a 34,600 μf
b 97,200 μf

13.19 a 550 μf
b 10.7 amp C 9.1 amp

13.20 b 0.067 watt

13.21 A 1.67 watts
b 1.48 watts

13.23 19 ohms

CHAPTER 14

14.2 $\frac{1}{\sqrt{L(C_1+C_2)}}$; $\frac{1}{\sqrt{LC_2}}$

14.3 $\frac{1.617}{\sqrt{LC}}$; $\frac{1}{\sqrt{LC}}$; $\frac{1.62}{\sqrt{LC}}$

14.6 a 44,000 ohms b 33,300 ohms
C 9.09 μmhos

14.7 $\sqrt{L/C}$ ohms

14.8 $K/\langle (j\omega)^3 LJ + (j\omega)^2 RJ + j\omega K^2 \rangle$

14.11 a $(1 + j\omega RC)/R$

14.16 8.33 watts, 4.17 var lagging;
9.09 mwatts, 4.54 mvar

14.28 $(s^2+2s+1)/(s^2+2s+2)$
Double zero at s=1, poles at
$-1 \pm j1$

14.34 a $(1 + 0.01s)(1+0.03s)$

14.35 $1/(s^2R^2C^2 + 3sRC + 1)$

14.36 a $(1-s\sqrt{LC})/(1+s\sqrt{LC})$

14.37 a $K/(s^3+2s^2+s+K)$

b $-1.755,\ 0.122 \pm j0.744;$
$-2,\ \pm j1;$
$-2.175, 0.0875 \pm j1.172$

14.39 $\epsilon^{-2t}(A\cos 15t + B\sin 15t)$

14.42 a $(1+s)/(2+s)$

b $A\epsilon^{-t},\ A\epsilon^{2t}$

CHAPTER 15

15.5 b 131,000 ohms, 575 μμf

15.6 a $0.175\ (1+0.475)/(1+0.0825s)$

15.7 a $1/(s^2R^2C^2 + 3sRC+1)$

15.11 a $1/(s^2LC + 2s\sqrt{LC} + 2)$

b $1/\sqrt{(2-\omega^2LC)^2 + 4\omega^2LC}$

15.12 $\omega_2 = 3750$ rad/sec,
$\omega_1 = 2920$ rad/sec

15.14 133 cps, 1/4

15.17 $1330 < f < 1670$

15.18 24 ohms, 48 mh, 5.2 μf

15.19 $Q \geq 3.54$

15.24 318 cps 1/5,5

15.26 35.8 k

15.27 a $8.0 \times 10^{-4}\epsilon^{-100t}$ joules

15.28 a $(R+sI)/(1+sRC+s^2LC)$

15.32 a $(R + j\omega L)/((1-\omega^2LC) + j\omega RC)$

15.34 a a= 0.855", b=0.57",
c=0.513", n=820

b 223

15.35 a 30.8 b 25

15.36 a 1300 cps b 11.1
c 73 ohms, 9000 ohms d 117 cps

15.37 20.3

15.38 1.45 v

15.40 0.0159

15.42 203 μμf, 0.0198, 50.5, 163 kohms

CHAPTER 16

16.5 a $f(t) = \frac{1}{T} + \sum_{n=1}^{\infty} \frac{2}{n\pi w}\sin\frac{n\pi w}{T}\cos\frac{2n\pi}{T}t$

16.6 $e(t) = 1 - \frac{2}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}\sin 200\,n\pi t$ v.

16.7 $\frac{2E}{\pi}\sum_{n=1}^{\infty}\frac{1}{n}(\sin\frac{n\pi}{3} - \cos\frac{2n\pi}{3})\sin 2000n\pi t$

16.9 a $f(\theta) = \frac{A}{\pi}(1 + \frac{\pi}{2}\cos\theta + \frac{2}{3}\cos 2\theta -$
$\frac{2}{15}\cos 4\theta + \ldots + (-1)^{\frac{n}{2}+1}\frac{2}{n^2-1}\cos n\theta + \cdots)$
[n even save for n=1]

b 1.21

16.10 a $f(\theta) = \frac{2A}{\pi}(1 - \frac{2}{3}\cos 2\theta - \frac{2}{15}\cos 4\theta - \ldots$
$- \frac{2}{n^2-1}\cos n\theta)$ n even

b 0.484

16.12 207

16.13 1.78 amp

16.14 exactly, $F_{eff} = A(\sqrt{3}/3 \approx 0.577A$,
approximately, $F_{eff} = 0.576A$

16.17 12.5 watts

16.18 89.4 watts

16.22 $f(\theta) = \frac{A}{2} + \sum_{n=1}^{\infty}\frac{A}{n\pi}\sin\frac{n\pi}{2}\epsilon^{jn\theta}$

16.23 $f(\theta) = \frac{I}{3} + \sum_{\substack{N=-\infty \\ N \neq 0}}^{\infty} \frac{I}{n\pi} \sin \frac{n\pi}{3} jn\theta$

16.24 $f(\theta) = 1 + \sum_{\substack{n=-\infty \\ n \neq 0}} \frac{j}{n\pi} \epsilon^{jn\theta}$

16.25 $i = 0.628 \cos 3140t + 0.252 \cos 6280 + 0.094 \cos 9420t$ amp.

16.26 a $i = 2.26 \cos \omega_f t + 1.13 \cos 3\omega_f t$ amp.

b $200 + 145 \cos (\omega_f t - 38.5^\circ) + 58 \cos (3\omega_f t - 15^\circ)$ v.

c 229 v.

16.29 11 μf, 0.097%

16.30 a $1/\alpha + j\omega$

16.31 a $2E/j\omega(1 - \cos \omega T)$

b 230 to 45,000 cps

16.32 c $f > 3.55$ cps

CHAPTER 17

17.2 77 turns

17.3 147 volts

17.4 a 181 turns

17.5 a $v_L = E\epsilon^{-Rt/L}$

b $v_2 = (N_2/N_1) E\epsilon^{-Rt/L}$

c $0.05\ L/R$

17.6 a 135 turns, 56 turns

b 5.55 amp, 13.4/2 amp, 0.67 kva.

17.8 $L_{inc} = \frac{1.13 \times 10^{-2}}{d}$ for $d > 2.51 \times 10^{-3}$ m.,

$L_{inc} = 0$ for $d < 2.51 \times 10^{-3}$ m.

17.9 0.30 mm

17.11 a 37.7 volts b $\frac{1}{240}$ sec.

17.12 b $\frac{E}{4N\phi_s}$ cps.

17.13 75 + j100 ohms

17.15 90 v., 6.0 amp., 360 v., 1.5 amp

17.16 a a = 8.15 b $\frac{1}{3}$ watt

17.17 a = 141

17.20 b 2 cps., 36 cps

17.22 b $K_{min} = \sqrt{2R_2/\omega L_2} = \sqrt{2/Q_2}$

17.23 a $I'/I_L = 1 - N_L/N_H$

17.24 c 4000 v.

17.25 a 25.4 cps b 16.4 cps

17.26 a 31 kc b 0.0845 μf, Q = 2.28

17.28 $L_{mag} = 15.8$ hy, $R_{eq} = 196$ ohms, $L_{leak} = 34.9$ mh.

17.29 a referred to the primary:

$R_c = \frac{(115)^2}{295}(20)^2 = 20{,}400$ ohms,

$X_m = 48{,}000$ ohms,

$R_{series} = 17.6$ ohms,

$X_{series} = 44.5$ ohms

Referred to secondary:

$R_c = 51$ ohms, $X_m = 120$ ohms,

$R_{series} = 0.044$ ohms.

$X_{series} = 0.111$ ohms

b 106 volts, 161 amp, 8.16 amp

c 94.5%

18.4 100v., 173v., 200 v.
18.5 177 v., 307 v.
18.7 a 48.9 amp
b 91.2 v.
c 86 kw
18.8 b 17.0 amp, 2640 w
18.11 a $F_p < 0.5$
18.13 A reads 1040 watts,
B reads 1040 watts
18.14 Both read 3120 watts
18.15 120 v., 12.0 amp, 2590 w.
18.16 208 v, 20.8 amp, 36.0 amp, 7800 w.
18.17 5.93 amp, 55.9v., 97 v.
18.18 13.4 amp, 84 v.
18.19 No
18.21 a 9470 w.
b 19,000 v.a.
c 0.50
18.22 a 53.4 ohms b 17.8 ohms
18.23 a 26.1 amp b 2940 var.
c 53.8 μf d 161 μf
e same
18.25 a 180 v., 30 v.
18.27 Phase a, 9.3 + j6.3, -1.67 - j4,
2.37 - j2.33
18.29 21.1 v.
18.30 131 v.
18.31 10.4 ohms
18.32 a 173.2 v
b 346.4 v.
c 200 v.
18.33 89.1 v., 47.4 v.